J Raptor Res. 33(1):43–48

PREVENTING BIRDS OF PREY PROBLEMS AT TRANSMISSION LINES IN WESTERN EUROPE

PATRICK BAYLE
15 rue Bravet, 13005 Marseille, France

Among the 37 species of birds of prey (28 falconiforms and 9 strigiforms) that breed or winter regularly in western Europe, at least 30 (24 falconiforms and 6 strigiforms) have been killed on powerlines, either through electrocutions or, to a lesser extent, through collisions with electric wires. Mortality on medium voltage distribution lines plays an important role in the global mortality of certain eagles, especially among juveniles (e.g., Spanish Imperial Eagle [*Aquila (heliaca) adalberti*] in Spain and Bonelli's Eagle [*Hieraaetus fasciatus*] in Spain and southern France) and is responsible for the general decline of these species. Powerlines also have an important impact on some common birds of prey, both regionally (e.g., Eurasian Eagle Owl [*Bubo bubo* in the southern French Alps) and locally (e.g., Eurasian Kestrel [*Falco tinnunculus*] in different areas in France). Different devices have been developed to assure a better isolation between electric wires and pylons and to prevent birds from perching on electric poles, but the most efficient protection is to bury the lines. Countries such the Netherlands (which have already achieved this aim), Belgium, Germany and the U.K. now intend to bury all their medium voltage lines.

BIRDS OF PREY VS. POWERLINES IN WESTERN EUROPE

One of the major factors causing declines in raptor populations is pollution, but forms of disturbance such as habitat loss and persecution have adverse effects on raptors (Newton 1979, Gensboel 1984). Accidental deaths that come to notice usually involve collisions of raptors with vehicles, buildings and other structures (Newton 1979). One of the human causes of mortality, which has been overlooked in Europe, is the powerline web with which raptors collide or electrocute themselves. For certain species, collisions and electrocutions on overhead wires form a major part of the total mortality and in extreme cases they may have contributed to raptor declines. This type of mortality is a major threat for species such as Bonelli's (Real et al. 1996) and Spanish Imperial Eagles (Ferrer and Hiraldo 1990).

Investigations in Germany, France and Spain show that, among the 37 species of raptors that breed or winter regularly in western Europe, at least 30 species have been victims of powerlines (Table 1). Raptors most often found dead under powerlines are common species such as Common Buzzards (*Buteo buteo*), Black Kites (*Milvus migrans*) and Eurasian Kestrels.

Medium voltage powerlines (1–60 kV) are responsible for most of the raptor mortalities on electric lines. In France, 96.5% of 649 birds of prey found dead under transmission lines were under medium voltage powerlines (Sériot and Rocamora 1992). The low impact of high or very high voltage powerlines (60–>150 kV) on raptors is illustrated by studies of the avian mortality on portions of such lines in the Netherlands (Heijnis 1980), Germany (Hoerschelmann et al. 1988), France (Bayle and Iborra unpubl. data) and Italy which show that birds of prey represent between only 0.1–0.4% of all birds killed on these lines. In the French study (Sériot and Rocamora 1992), all birds of prey found under high or very high voltage powerlines were killed by collision with transmission lines. Since then an immature Bonelli's Eagle is known to have died from electrocution on a 63-kV power structure near Marseilles in August 1992 (Cheylan and Bayle unpubl. data). Of the raptors killed on medium voltage powerlines, 93.5% were electrocuted and 6.5% collided against electric wires.

In France and Spain, the role of powerlines in the general mortality of raptors has been studied recently in species with small populations such as the Spanish Imperial Eagle (Ferrer and Hiraldo 1990), Golden Eagle (*Aquila chrysaetos,* Couloumy 1993), Bonelli's Eagle (Real et al. 1996) and Griffon Vulture (*Gyps fulvus,* Terrasse et al. 1994). Since this form of mortality affects mainly juvenile birds, it can have an important impact on the population dynamics of these species and be critical for their survival. Between 1974–88, 51.5% of 68

Table 1. Raptor species affected by mortality on electric powerlines in three European countries (Germany, France and Spain).

SPECIES	D[a]	F	E
Osprey (*Pandion haliaetus*)		+[b]	
Common Buzzard (*Buteo buteo*)	+++	+++	+++
Rough-legged Buzzard (*Buteo lagopus*)	+		
Honey Buzzard (*Pernis apivorus*)	+	+	
Black Kite (*Milvus migrans*)	+	+	+++
Red Kite (*Milvus milvus*)	++	+	++
Short-toed Eagle (*Circaetus gallicus*)		+	+
Bonelli's Eagle (*Hieraaetus fasciatus*)		+	++
Booted Eagle (*Hieraaetus pennatus*)		+	+
Golden Eagle (*Aquila chrysaetos*)	+	+	+
Spanish Imperial Eagle (*Aquila (heliaca) adalberti*)			+
Bearded Vulture (*Gypaetus barbatus*)		+	
European Black Vulture (*Aegypius monachus*)			+
Griffon Vulture (*Gyps fulvus*)		+	+
Egyptian Vulture (*Neophron percnopterus*)			+
European Sparrowhawk (*Accipiter nisus*)		+	
Northern Goshawk (*Accipiter gentilis*)	+	+	++
Marsh Harrier (*Circus aeruginosus*)		+	
Hen Harrier (*Circus cyaneus*)	+		
Montagu's Harrier (*Circus pygargus*)			+
Peregrine Falcon (*Falco peregrinus*)		+	+
European Hobby (*Falco subbuteo*)		+	+
Merlin (*Falco columbarius*)		+	
Eurasian Kestrel (*Falco tinnunculus*)	+++	+++	+
Barn Owl (*Tyto alba*)	+	++	+
Eurasian Eagle Owl (*Bubo bubo*)	+	++	+
Long-eared Owl (*Asio otus*)	+	+	
Short-eared Owl (*Asio flammeus*)		+	
Little Owl (*Athene noctua*)		+	+
Tawny Owl (*Strix aluco*)	+	+	++
Total number dead under powerlines	567	686	1282

[a] D—Germany (Haas 1980), F—France (Sériot and Rocamora 1992, Niebuhr pers. comm.), E—Spain (Haas 1980, Castano and Guzman 1989, Mugica 1989, Negro and Manez 1989, Ferrer et al. 1991, Agrupacion Naturalista Esparvel 1993 and Segara and Martos 1993).

[b] + <5%, ++ 5–10% and +++ >10% of the total number of raptors found dead under powerlines.

Spanish Imperial Eagles found dead in Doñana National Park (Spain) were electrocuted. After isolation or burial of powerlines in 1987, juvenile survival increased from 17.6% in 1986–87 to 80.0% in 1988–89 (Ferrer and Hiraldo 1990). In northeastern Spain (Alicant, Murcia and Catalonia) and southern France (Languedoc-Roussillon and Provence) powerlines were responsible for 44.8% of the known mortalities of Bonelli's Eagles between 1980–93 (N = 58). The situation varied greatly from one region to another with only 5.2% of the birds found dead in Murcia dying on powerlines as opposed to 38.0% dying on powerlines in Catalonia and 82.6% in southern France (Real et al. 1996). In the latter area where the total breeding population is estimated to consist of only 28 pairs, among 20 ringed juveniles found dead between 1990–95, 17 were killed on powerlines (Cheylan et al. 1996). All Bonelli's Eagle populations in northeastern Spain and southern France are declining and, in some areas (Alicant and Murcia), the abrupt decrease in population size seems to be a consequence of high adult mortality through direct persecution. In other areas (Catalonia and southern France) where adult mortality is lower, the decline has been more moderate and has been

Table 2. Percent of general avian mortality on electric powerlines in "Important Bird Areas" (IBAs) in the Plain of Crau and its vicinity (Bouches-du-Rhône, southeastern France), 1988–93.

TYPE OF BIRD	A[a]	B	C
raptors (Falconiformes/Strigiformes)	40.0	14.0	0.2
corvids (Corvidae)	45.0	10.3	0.5
gulls and terns (Laridae)	3.0	15.9	61.6
herons (Ardeidae)	0.0	43.0	0.6
White Stork (*Ciconia ciconia*)	6.0	0.0	0.0
Greater Flamingo (*Phoenicopterus ruber*)	0.0	3.7	14.1
other birds	6.0	13.1	23.0
Total (*N*)	100	107	865

[a] A—electrocutions on medium voltage (<60 kV) distribution lines in the Plain of Crau (IBA PAC 03) (Kabouche 1991, Bayle unpubl data). B—electrocutions and collisions on medium voltage distribution lines in the Vigueirat marshes (IBA PAC 08) (Hecker et al 1992, Lucchesi unpubl. data). C—collisions on very high voltage (>150 kV) distribution lines in the saltworks of Fos-sur-Mer (IBA PAC 15) (Bayle unpubl. data).

mainly a consequence of habitat destruction and high preadult mortality due to electrocution (Real et al. 1996).

Raptors other than eagles and vultures are also affected by powerlines but it is difficult to assess the severity of the mortality since it varies greatly from one population and geographical area to another. For example, powerlines were responsible for 22.6% of identified cases of mortality of Eurasian Eagle Owls in Sweden (Olsson 1979) and Finland (Saurola 1979 in Mikkola 1983), 32.5% in Germany (Wickl 1979), 54.7% in France (Bayle 1992 and unpubl. data) and 16.3% in Spain (Hernandez 1989). In the southern Alps and Mediterranean area, the proportion of Eurasian Eagle Owls killed by powerlines varied from 45.5% in the Mediterranean area ($N = 66$) to 88.9% in the Alps ($N = 18$). The "electrification" of landscapes seems to be the major limiting factor of the alpine population of Eurasian Eagle Owls and may be the explanation for the decline of the species in the Swiss and French Alps (Haller 1978, Bayle 1992), as well as in the Italian Apennines (Penteriani and Pinchera 1991).

Powerlines typically kill the smaller, more common raptors (Table 1). In France, Eurasian Kestrels are very frequent victims mainly because of massive electrocutions on certain medium voltage lines (Deschamps 1980, Brochet 1993). In one case, 130 kestrels, one European Hobby (*Falco subbuteo*), four Common Buzzards and 32 other birds were found in four years (1988–91) on a 5-km portion of a 20-kV powerline (Brochet 1993).

Most powerlines are deadly because the configuration of structures that support them makes raptors vulnerable (Deschamps 1980, Haas 1980, Sériot and Rocamora 1992, Ferrer et al. 1993). The problem is magnified when these powerlines traverse important raptor areas such as territories with important raptor breeding populations (e.g., near vulture colonies) or terrains which attract large numbers of birds of prey (e.g., hunting grounds such as marshlands or steppes). For example, significant raptor mortality on medium voltage lines has been recorded at Doñana National Park in Spain (Haas 1980, Ferrer et al. 1991) and in southeastern France near the plain of Crau and its surroundings (marshes to the west and saltworks to the south). This area in France is a hunting territory for Short-toed Eagles (*Circaetus gallicus*) in the postnuptial period, a wintering area for Red Kites (*Milvus milvus*) and a major part of the juvenile Bonelli's Eagles in France use this area. These sites have been classified among the "Important Bird Areas" (IBAs) according to Birdlife International standards (Rocamora 1994). They are also close to densely urbanized and industrialized zones with considerable density of electric lines of all types. This has resulted in a significant avian mortality for Black Kites and Short-toed and Bonelli's Eagles (Tables 2, 3).

PREVENTING RAPTOR PROBLEMS AT TRANSMISSION LINES

Before trying to prevent raptor problems at transmission lines, the first step is to assess the impact of powerlines on these birds. This can only be done by conducting thorough surveys under powerlines to determine which portions of the network are dangerous for birds of prey.

Contacts must then be made with the power

Table 3. Raptor mortality on electric powerlines in Important Bird Areas (IBAs) in the Plain of Crau and its vicinity (Bouches-du-Rhône, southeastern France), 1988–93.

SPECIES	A[a]	B	C
Common Buzzard (*Buteo buteo*)	5	3	0
Black Kite (*Milvus migrans*)	15	2	0
Red Kite (*Milvus milvus*)	1	0	0
Buzzard or kite (*Buteo/Milvus*)	3	0	0
Short-toed Eagle (*Circaetus gallicus*)	5	5	0
Bonelli's Eagle (*Hieraaetus fasciatus*)	4	4	0
Short-toed or Bonelli's Eagle	1	0	0
European Sparrowhawk (*Accipiter nisus*)	0	0	1
Eurasian Kestrel (*Falco tinnunculus*)	3	1	0
unidentified falconiform	2	0	0
Long-eared Owl (*Asio otus*)	0	0	1
Eurasian Eagle Owl (*Bubo bubo*)	1	0	0
Total (*N*)	40	15	2

[a] A—electrocutions on medium voltage (<60 kV) distribution lines in the Plain of Crau (IBA PAC 03) (Kabouche 1991, Bayle unpubl. data). B—electrocutions and collisions on medium voltage distribution lines in the Vigueirat marshes (IBA PAC 08) (Hecker et al. 1992, Lucchesi unpubl. data). C—collisions on very high voltage (>150 kV) distribution lines in the saltworks of Fos-sur-Mer (IBA PAC 15) (Bayle and Iborra unpubl. data).

companies to inform, sensitize and convince them that it is necessary to prevent raptor mortality on their networks. It is elusive to expect that any type of problem on powerlines will be solved without the cooperation of the power companies.

Proposed methods to reduce avian mortality on powerlines must first be tested with mock poles and wires and slow motion film or video, either on captive birds in specially designed aviaries (studies carried out in France by the "Union Nationale des Centres de Sauvegarde de la Faune Sauvage") or on trained birds in the field (Nelson and Nelson 1977), to see how the birds react to the devices. This experimental phase is often overlooked by power companies (mainly for financial reasons) but is, by no means, superfluous. For example, in France, 55 poles were equipped with a plastic, spiral prototype on a 5-km-long portion of a 20-kV powerline to stop massive electrocutions of kestrels; during the year that followed, 62 of kestrels and one hobby were found electrocuted under the supposedly neutralized poles (Brochet 1993).

All powerline portions with high risks for raptors must be modified to avoid avian mortality. On lines where collisions occur this can be done by installing warning devices on the wires (such as colored plastic spirals) or by setting up frightening objects on the poles (such as oversized raptor silhouettes) in order to drive the birds away from the lines (Raevel and Tombal 1991). Different devices have been developed to reduce electrocution, either by assuring a better isolation between electric wires and pylons (for example by isolating the wire or the pole with a plastic sheath) or by preventing birds from perching on electric poles (Vereinigung Deutscher Elektrizitätswerke 1991). Pylons can also be modified, especially to protect large raptors, by adding a special perch above the wires.

All lines must be checked after they have been equipped in order to test the efficiency of the devices. For example, taper-like plastic poles which were placed on dangerous pylons around the colony of reintroduced Griffon Vultures in the French Cévennes National Park were inefficient and did not prevent the electrocution of two young birds which managed to perch between the obstacles (Terrasse pers. comm.).

Although some European power companies are very satisfied with these devices and argue that they reduce avian mortality by 90–95%, most of them can be considered as only expedients. As far as medium voltage powerlines are concerned, an underground network is the only totally efficient solution to raptor mortality. There are no technical problems for the burial of medium tension lines and, at least in the small and densely populated European countries, the financial costs are equivalent to those for the setting up of overhead lines. All voltage powerlines in the Netherlands are underground and other west European countries intend to bury all their medium voltage lines in the near future. At the beginning of the 1990s, 77% of the transmission lines in Belgium were already underground, 56% in (West) Germany and 44% in the U.K., but south European countries such as Italy, France and Spain are well behind with only 22%, 19% and 13%, respectively, of their medium voltage lines buried (Vallet 1991, Anonymous 1993). These figures explain why the mortality of raptors on powerlines is so acute in the two latter countries, although other factors such as powerline configuration and raptor densities may also greatly influence the situation. The conservation community must insist that power companies (and governments) undertake measures to enforce the burial of the whole network in order to suppress avian mortality on medium tension lines. In countries such as France and Spain where so much still

needs to be done, it cannot be reasonably expected that all lines will be buried soon. Priority actions on problem powerlines must be determined on a national level between conservation groups and power companies. In France, for example, the two main bird protecting societies, the "Ligue pour la Protection des Oiseaux" (LPO) and the "Fonds d'Intervention pour les Rapaces" (FIR) have listed eight priority bird species, among which are Ospreys (*Pandion haliaetus*), Red Kites, Bonelli's Eagles, Golden Eagles, Griffon Vultures and Eurasian Eagle Owls, as well as White Storks (*Ciconia ciconia*) and Common Cranes (*Grus grus*). Conservation measures should first be undertaken on lines that lie across natural landscapes with large populations of raptors or which shelter endangered species. Such sites are already listed among IBAs and sometimes protected as Ramsar Sites or as natural reserves with a bird conservation vocation. LPO and FIR have asked the national power company "Electricité de France" (EDF) to cooperate in the establishment of a national action plan on these bases. To this date, EDF refuses to recognize the need to inventory priority zones. EDF concedes today that preventing bird of prey mortality on powerlines cannot be considered anymore as a major technical problem (Vallet 1991).

LITERATURE CITED

AGRUPACION NATURALISTA ESPARVEL. 1993. La electrocucion de rapaces en la provincia de Toledo. *Quercus* 94: 24–29.

ANONYMOUS. 1993. La France en retard pour l'enfouissement des lignes. *L'Environnement-Magazine* 1521:44.

BAYLE, P. 1992. Le Hibou grand-duc *Bubo bubo* dans le Parc National du Mercantour et ses environs. P.N. Mercantour, Nice, France.

BROCHET, J. 1993. Expérimentation des prototypes spirale (SAAE) et Piver (RAYCHEM) sur les lignes EDF MT 20.000 volts Compertrix—Haussimont (1991–92). LPO & EDF, Rochefort, France.

CASTANO, J.P. AND J. GUZMAN. 1989. Mas de 70 rapaces mueren electrocudas en dos tendidos electricas de Ciudad Real. *Quercus* 40:41.

CHEYLAN, G., A. RAVAYROL, J.-M. CUGNASSE, J.-M. BILLET AND C. JOULOT. 1996. Dispersion des aigles de Bonelli *Hieraaetus fasciatus* juvéniles bagués en France. *Alauda* 64:413–419.

COULOUMY, C. 1993. Causes de mortalité de l'Aigle royal en région Provence—Alpes—Côte d'Azur. *Faune & Nature (Bull. ARPON)* 35:9–13.

DESCHAMPS, P. 1980. Point local sur l'électrocution des rapaces (et autres oiseaux) sur les lignes à moyenne tension de la région grenobloise. *La Niverolle* 5:59–66.

FERRER, M. AND F. HIRALDO. 1990. Evaluation of management techniques for the Spanish Imperial Eagle. *Wildlife Soc. Bull.* 19:436–442.

———, M. DE LA RIVA AND J. CASTROVIEJO. 1991. Electrocution of raptors on power lines in southwestern Spain. *J. Field Ornithol.* 62:181–190.

———, G. JANSS AND M.L. CHACON. 1993. Mortalidad de aves en tendidos electricos: situacion en Espana. *Quercus* 94:20–23.

GENSBOEL, B. 1984. Collins Guide to the birds of prey of Britain and Europe, North Africa and the Middle East. Collins, London, U.K.

HAAS, D. 1980. Gefährdung unserer Grossvögel durch Stromschlag—eine Dokumentation. *Oekol. Vögel* 2 (Sonderheft):7–57.

HALLER, H. 1978. Zur Populationsökologie des uhus *Bubo bubo* im Hochgebirge: Bestand, Bestandesentwicklung und Lebensraum in den Rätischen Alpen. *Orn. Beob.* 75:237–265.

HECKER, N., A. MANTE AND J.-L. LUCCHESI. 1992. Etude de la réaction des oiseaux aux différents systèmes de visualisation de la ligne moyenne tension sur le domaine du Vigueirat (commune d'Arles, Bouches-du-Rhône). Station Biologique de la Tour du Valat, Arles, France.

HEIJNIS, R. 1980. Vogeltod durch Drahtanflug bei Hochspannungsleitungen. *Oekol. Vögel* 2 (Sonderheft.):111–129.

HERNANDEZ, M. 1989. Mortalidad del buho real en Espana. *Quercus* 40:24–25.

HOERSCHELMANN, H., A. HAACK AND D.F. WOHLGEMUTH. 1988. Verluste und Verhalten von Vögeln an einer 380-kV-Freileitung. *Oekol. Vögel* 10:85–103.

KABOUCHE, B. 1991. Une prospection des réseaux électriques de moyenne tension autour de St.-Martin-de-Crau (Bouches-du-Rhône). CEEP, Aix-en-Provence, France.

MIKKOLA, H. 1983. Owls of Europe. T. & A.D. Poyser, Calton, U.K.

MUGICA, A. 1989. Aves electrocudas en la Comunidad de Madrid. *Quercus* 39:29.

NEGRO, J.J. AND M. MANEZ. 1989. Impacto de los tendidos sobre la avifauna. *Quercus* 39:25–29.

NELSON, M. AND P. NELSON. 1977. Power lines and birds of prey. Pages 228–242 *in* Chancellor and Meyburg [EDS.], 1st World Conference on Birds of Prey, Vienna, 1975, Berlin, Germany.

NEWTON, I. 1979. Population ecology of raptors. Poyser, Berkhamsted, U.K.

OLSSON, V. 1979. Studies on a population of Eagle Owls *Bubo bubo* (L.) in southeast Sweden. *Viltrevy* 11:1–99.

PENTERIANI, V. AND F. PINCHERA. 1991. Densité, distribution et causes du déclin d'une population de Hiboux grands-ducs, *Bubo bubo,* dans les Abruzzes (centre de

l'Italie). Rapaces Nocturnes—Actes du 30e Colloque interrégional:189–193.

RAEVEL, P. AND J.-C. TOMBAL. 1991. Impact des lignes haute-tension sur l'avifaune. *Aménagement et Environnement* 1:1–56.

REAL, J., S. MANOSA, G. CHEYLAN, P. BAYLE, J.-M. CUGNASSE, J.A. SANCHEZ, M.A. SANCHEZ, D. CARMONA, J.E. MARTINEZ, L. RICO, J. CODINA, R. DEL AMO AND S. EGUIA. 1996. A preliminary approach to the European Bonelli's Eagle population decrease in Spain and France. Pages 523–528 *in* B.-U. Meyburg and R.D. Chancellor [EDS.], Eagle studies. World Working Group on Birds of Prey and Owls, Berlin, Germany.

ROCAMORA, G. 1994. Les zones importantes pour la conservation des oiseaux en France. LPO, Rochefort, France.

SEGARA, D. AND J.A. MARTOS. 1993. Trampa mortal en las lineas de alta tension. *La Vanguardia* 18/09/93:8–9.

SÉRIOT, J. AND G. ROCAMORA. 1992. Les rapaces et le réseau électrique aérien. Analyse de la mortalité et solutions. LPO & EDF, Rochefort, France.

TERRASSE, M., C. BAGNOLINI, J. BONNET, J.-L. PINNA AND F. SARRAZIN. 1994. Reintroduction of the Griffon Vulture *Gyps fulvus* in the Massif Central, France. Pages 479–491 *in* B.-U. Meyburg and R.D. Chancellor [EDS.], Raptor conservation today. World Working Group on Birds of Prey and Owls, Berlin, Germany.

VALLET, G. 1991. Développement des réseaux souterrains HT en rural. Guide Technique de la Distribution d'Electricité, document A.15-1. EDF GDF Services, Paris, France.

VEREINIGUNG DEUTSCHER ELEKTRIZITÄTSWERKE. 1991. Vogelschutz an Starkstrom-Frei-leitungen mit Nennspannungen über 1 kV, 2. Auflage. VWEW-Verlag, Frankfurt-am-Main, Germany.

WICKL, K.-H. 1979. Der Uhu (*Bubo bubo*) in Bayern. *Garmischer Vogelkundliche Berichte* 6:1–47.